Title: Tomato IPM on Farm Demonstrations

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Cooperator(s): The three cooperating growers that participated in this project.

Abstract:
IPM practices in tomatoes were demonstrated at three different farms this year. All three farms participated in side by side comparisons between grower practices and IPM protocols. For each farm, data on pest levels, pesticide use, and damage at harvest were collected. Each field was scouted weekly for insect and disease pests. Disease samples were brought to Cornell's Plant Disease Diagnostic Clinic for identification. TOMCAST, a disease forecasting program, and BlightPro Decision Support System, a late blight management tool, were used when appropriate. Growers received weekly scouting reports and treatment recommendations. At the end of the season a harvest evaluation was conducted for both the grower managed portion and the IPM portion of the fields. The overall EIQ (Environmental Impact Quotient) for each farm was also determined. For all three farms the growers reported that having someone scout their tomatoes was extremely helpful and that pests they were unaware of were identified and treated.

Background and justification:
New York state is the 6th largest fresh market tomato producing state based on production value (2015 USDA Annual Vegetable Summary). According to the 2015 USDA National Agricultural Statistics Service, fresh market tomatoes were planted to 2,500 acres in NY and had a value of $31.4 million. There are many disease pests of tomatoes that result in high numbers of fungicide sprays. By using IPM procedures in conjunction with forecast models such as TOMCAST and Blight Pro, fungicide applications could potentially be reduced. Through on farm demonstrations growers can learn pest identification and threshold levels for the various pests. Knowing when a pest has reached threshold can help time sprays better and hopefully reduce the overall numbers of sprays required to control a pest.

Objectives:
1. Work with CCE field staff to identify farmers to host tomato IPM demonstrations.
2. Interview growers to establish pre-season expectations
3. Use split-field plots, side by side demonstrations comparing grower practices with the IPM protocols, at three locations.
4. Begin weekly scouting in both areas of the field and monitor forecast models for each of the participating farms
5. Provide growers with weekly scouting reports along with pest management recommendations.

6. Conduct harvest evaluations at time of harvest and post season interviews.

Procedures:

1. Three growers participated in the demonstrations, one in Erie county, one in Monroe county, and one in Onondaga county.
2. All growers were interviewed prior to the start of the demonstrations to determine their typical pest management practices and pest damage levels.
3. One tomato field for each of the three participating growers was divided into two portions, one where the grower used their typical management practices and the other portion where they followed IPM protocols to determine if an application was needed.
4. Fields were scouted weekly for insects and diseases based on *Fresh Market and Processing Tomato IPM Scouting Procedures* (See Seaman and Petzolt 2000). The farm locations were entered into TOMCAST for all three farms and into Blight Pro for the Onondaga farm, the only farm with a NEWA station within a reasonable distance. Growers were provided with scouting reports and spray recommendations for the IPM part of the field. If bacterial speck, spot, or canker was detected in the field, TOMCAST was discontinued and copper applications were recommended.
5. After scouting fields, the scouting forms were given to the growers with recommendations on whether a spray application was necessary based on thresholds.
6. Harvest evaluations were conducted on each portion of the field by evaluating 10 fruit at each of 10 locations for insect and disease damage. Post season interview questions were sent to all participants to gauge their overall impressions of the demonstrations, their harvest, and to address any concerns they may have.

Scouting and Harvest Evaluation Results:

<u>Erie County</u>

The Erie county site consisted of a 1.85-acre field of grape tomatoes. The field was divided into four blocks of ten rows each. The IPM portion of the field consisted of the western most block of ten rows. It was approximately .35 acres in size. The remaining 30 rows, approximately 1.5 acres, were the grower's portion of the field. The grower had two additional tomato plantings located on the farm.

During the initial interview the grower mentioned yearly problems with two-spotted spider mites (TSSM) in the demonstration field. The mites seem to originate in the western most portion of the field (the IPM portion) beginning in early July and result in a three-day spray schedule to keep them under control. Knowing that this is a yearly problem for him, beneficial mites were ordered and released on June 30th. The beneficial mites, *P. persimilis* (6000 mites) and *N. fallacis* (5,000 mites) were released at the recommended rate and time to control TSSM.

Weekly scouting began on June 23rd and continued until harvest, September 15th. The first TSSM was detected in the IPM portion of the field on June 23rd and in the grower's portion of the field on August 11th. Weekly leaf samples were taken to determine if the beneficial mites

were still present. No beneficials were ever detected and miticide application were recommended beginning August 17th when TSSM damage was visible.

This year, 2016, was an extremely hot dry year favorable for mites but not for fungal diseases. A first fungicide application was recommended on July 18th based on weather conditions and TOMCAST. On August 8th confirmation was received form the Plant Disease Diagnostic Clinic that bacterial speck was present in the IPM portion of the field. TOMCAST forecasting was discontinued and it was recommended that copper sprays begin immedialty ensuring coverage is maintained as the plants grow.

The main diseases observed in the field as well as first detection are given in Table 1. The first detection of TSSM occurred in the IPM portion of the field, while early blight and septoria leaf spot were first detected in the grower portion of the field. The east side of the field (grower portion) is shaded by a hedgerow which kept the area cooler and moister than the rest of the field. The three rows on the eastern most side of the field also showed considerable wilt. The wilt was identified as walnut wilt (Figure 1) and attributed to the walnut trees that made up a large part of the hedgerow. The field had a history of bacterial speck and bacterial canker and it was recommended that the grower rotate for a minimum of three years.

Table 1. List of pests detected and date of first detection for the Erie county site.

Pest	IPM	Grower
TSSM[a.]	6/23/16	8/11/16
Alternaria stem canker	7/14/16	7/14/16
Bacterial Speck	7/21/16	7/21/16
Bacterial Canker	7/28/16	7/28/16
Septoria leaf spot	8/4/16	7/28/16
Early blight	8/4/16	7/28/16
Wilt	7/28/16	7/21/16

a. TSSM- two-spotted spider mite

At the time of the harvest evaluation, very little fruit showed any damage. Two harvest evaluation were conducted the first on September 8th and the second on September 15th. Both showed less than 5% damage with no significant differences between the IPM portion and the grower portion. The primary damage was due to bacterial speck. Since so little damage was seen on the tomato fruit a plant rating was done as well. These results are given in Table 2. The results are on a 0-9 scale where 0 is no damage and 9 is the plant is dead. Since the TSSM began in the IPM portion of the field and the beneficial mites did not seem to control them, the IPM portion showed significantly higher TSSM damage. Septoria leaf spot was the only other pest that showed a significant difference between the IPM portion and the grower portion, probably due to the wetter area in the grower portion of the field.

Table 2. Plant ratings (o-9 scale) for the IPM portion of the field and the grower portion of the field in Erie county.

	Plant rating (0-9 scale)				
Pest	**IPM**	**Grower**	**df**	**T stat**	**P[b.]**
TSSM[a.]	4.8	1.5	18	4.5	0.0003
Early blight	3.7	3.1	16	1.06	0.30
Septoria leaf spot	1.3	2.6	18	-2.7	0.015
Bacterial speck	2.1	3.1	14	-1.6	0.14
Bacterial canker	1.7	2	15	-0.6	0.55

a. TSSM - Two-spotted spider mite
b. P values determined using a t-Test (two-sample assuming unequal variances)

Due to the release of the beneficial mites, the grower did not begin any miticide sprays until much later in the season (see Table 3). Unfortunately, the beneficial mites were ineffective and TSSM quickly became the biggest problem in both the IPM and grower portion of the field. As soon as bacterial speck was confirmed in the field a copper application was recommended. The grower relies primarily on Oxidate for control of bacterial diseases and did not use copper. Oxidate works well if in direct contact with the bacteria but does not leave a residual. In addition to the products listed in Table 3, the grower also used Cell force as a foliar source of calcium and nitrogen, Molasses as a food source for beneficial soil microbes, fertilizer and Sugar express.

Table 3. Erie county pesticide application. All applications were on both the grower and IPM portions of the field.

Date	**Product**		**AI**	**Rate**	**EIQ**
7/3/16	Oxidate	antimicrobial	Hydrogen dioxide	1 qt/A	8.6
7/3/16	Regalia	biofungicide	*Reynoutria sachalinensis*	1 qt/A	
7/27/16	Oxidate	antimicrobial	Hydrogen dioxide	1 qt/A	8.6
7/27/16	Regalia	biofungicide	*Reynoutria sachalinensis*	1 qt/A	
8/4/16	Oxidate	antimicrobial	Hydrogen dioxide	48 oz/A	13
8/17/16	Oxidate	antimicrobial	Hydrogen dioxide	48 oz/A	13
8/17/16	Hero	Insecticide	Bifenthrin Zeta-Cypermethrin	10 oz/A	3.1
8/20/16	Portal	miticide	Fenpyroximate	2 pt/A	1.9
TOTAL					**118.2**

Overall, the harvest between the IPM portion of the field and the grower portion of the field was the same according to the grower. However, as compared to the rest of the farm, the demonstration field had one less picking as compared to the other two tomato plantings. This was due to the defoliation caused by the TSSM and the bacterial and fungal diseases that were present in this field but not in the other fields. Since the sprays on both portions of the field

were the same, there was no difference in EIQ values between the two portions of the field. The total EIQ was 118.2, which was the lowest of the three demonstration sites. The grower found the demonstration very helpful, especially for early detection and proper identification of diseases. He stated that he learned about new diseases that he did not know were present in his field and this will help him greatly in the future.

Monroe County

The Monroe county site was a .8-acre field consisting of six rows of tomatoes. Three rows were designated for the IPM portion and the other three rows were the grower's portion. Tomato varieties in the IPM portion consisted of Iron Lady, BHN 410, Roma and Scarlet Red and the grower's portion were Super Sweet, Sunkist and Early Girl. The tomatoes are grown mainly for CSA shares.

Weekly scouting began on June 22rd and continued until harvest, September 21th. The diseases observed in the field as well as the date of first detection are given in Table 4. Both bacterial speck and canker were detected in late June and confirmed by the Plant Disease Diagnostic Clinic on July 6th. At this point copper sprays were recommended and TOMCAST forecasting, which had not reach critical DSV (Disease Severity Value), was discontinued. It was recommended that the grower rotate for at least 3 years.

Throughout the season Colorado potato beetles and Potato aphids were seen but never reached threshold levels. Later in the season stink bugs became a problem and an insecticide was recommended. This site also had TSSM but they never reached threshold levels and only minor leaf stippling was observed.

Table 4. List of pests detected and date of first detection for the Monroe county site.

Pest	IPM	Grower
CPB[a.]	6/22/16	7/6/16
Bacterial speck	6/29/16	6/29/16
Bacterial canker	6/29/16	6/29/16
Early blight	7/13/16	7/27/16
SpLV[b.]	.	7/20/06
Potato aphid	7/20/16	8/3/16
Stink bug	8/3/16	8/3/16
Septoria leaf spot	8/24/16	.
TSSM	8/24/16	8/31/16
Alternaria stem canker	7/20/16	.
Anthracnose	9/14/16	8/31/16

a. CPB - Colorado potato beetle
b. SpLV - Spinach latent virus

Bacterial canker, bacterial speck and Early blight were the primary diseases observed at this location. A fruit sample with ring spots was taken and determined to be SpLV (Spinach latent virus), an emerging virus previously not found in NY. The virus is thought to be seed transmitted and could pose a threat to NY tomato production (Figure 2).

On September 8th, a harvest evaluation, consisting of 10 fruit inspected at ten different location was conducted for both the IPM and grower portions of the field. Results from the harvest evaluation are given in Table 5. Both the IPM and Grower side had about the same amount of clean fruit, nearly 75% and no significant differences were determined for any of the pests using Fischer's exact test. The greatest amount of damage came from stink bug feeding damage. Stink bugs were not observed until early August but they quickly increased in numbers and caused considerable damage, however, no insecticide applications were ever made to either portion of the field (see Table 6).

Table 5. Harvest evaluation for the IPM portion of the field and the grower portion of the field. Numbers represent total fruit out of 100.

	IPM	Grower	p
Clean	75	73	0.75
Stink bug	8	12	0.48
Bacterial speck	2	0	0.50
Anthracnose	6	5	1.0
Bacterial canker	3	5	0.72
Early blight	0	1	1.0
Zipper	1	1	1.0
BER[a.]	2	0	0.50
Other	3	3	1.0

a. BER - Blossom end rot

The total EIQ for both portions of the field are given in Table 6. Only one additional application of copper was made to the IPM portion as compared to the grower portion. As soon as bacterial speck and bacterial canker were detected a copper application was recommended to the IPM portion, thereafter both fields received the same sprays.

Table 6. Monroe county pesticide application for the Grower and IPM portions of the field.

Date	Product		AI	Rate	Grower	IPM	EIQ
7/20/16	Ridomil Gold Bravo	fungicide	Chlorothalonil Mefenoxam	2.5 pts/A	X		32.6
7/21/16	Ridomil Gold Bravo	fungicide	Chlorothalonil Mefenoxam	2.5 pts/A		X	32.6
7/21/16	Cuprofix	bactericide	Copper Sulfate	1.9 lbs/A		X	83.6
7/28/16	Previcur flex	fungicide	Propamocarb hydrochloride	1.1 pts/A	X	X	17.5

7/28/16	Manzate	fungicide	Mancozeb	1.5 qts/A	X	X	28.5
7/28/16	Cuprofix	bactericide	Copper Sulfate	1.9 lbs/A	X	X	83.6
8/11/16	Ranman	fungicide	Cyazofamid	2.4 fl oz/A	X	X	0.8
8/11/16	Bravo Weather Stik	fungicide	Chlorothalonil	1.7 pts/A	X	X	34.4
8/18/16	Quadris	fungicide	Azoxystrobin	5.6 fl oz/A	X	X	2.2
8/18/16	Cuprofix	bactericide	Copper Sulfate	1.9 lbs/A	X	X	83.6
8/24/16	Previcur flex	fungicide	Propamocarb hydrochloride	1.1 pts/A	X	X	17.5
8/24/16	Cuprofix	bactericide	Copper Sulfate	1.9 lbs/A	X	X	83.6
9/6/16	Revus top	fungicide	Mandipropamid Difenoconazole	6.25 fl oz/A	X	X	5.9
9/6/16	Cuprofix	bactericide	Copper Sulfate	1.9 lbs/A	X	X	83.6
TOTAL					**473.8**	**557.4**	

It was difficult for the grower to determine if the harvest for the two portions of the fields were the same as they are picked for CSA shares and total harvest for each variety was not available. Based on results from the harvest evaluation, no differences were found between the two portions of the field. The grower indicated that he usually does not apply as much copper, but based on the confirmation of both bacterial speck and canker in his field he applies more than he would have otherwise.

Onondaga County

The Onondaga county site consisted of a 20-acre field with nearly 30 varieties of tomatoes. The IPM portion of the field was about 3 acres and the growers portion was about 17 acres. Scouting began on June 15th and continued through harvest, September 13th. This site was the only one with a NEWA weather station close enough to use Blight Pro DSS for late blight forecasting.

The diseases observed in the field as well as the date of first detection are given in Table 7. This farm was also found to have both bacterial speck and bacterial canker. Bacterial speck was observed initially in the IPM portion of the field after the grower's portion had already received two applications of copper. The speck symptoms were seen only on the fruit, not on the leaves (Figure 3). Copper sprays were initiated in the IPM field as soon as this was identified and by the time the fruit was evaluated for harvest very little speck was found on the fruit.

In early August, the grower became concerned with damage that he attributed to early blight in his Mariana tomatoes (Figures 4 and 5). It was determined to be TSSM and miticide treatments were started. The mites were soon found throughout the field, but were kept under control.

Table 7. List of pests detected and date of first detection for the Onondaga county site.

Pest	IPM	Grower
TSSM[a.]	9/6/16	8/16/16
Stink bug	9/13/16	9/13/16
Early blight	7/19/16	7/19/16
Bacterial speck	7/26/06	8/9/16
Bacterial canker	8/30/16	9/6/16
Septoria leaf spot	.	7/12/16
Alternaria stem canker	7/12/16	7/19/16

a. TSSM- two-spotted spider mite

On September 6th, a harvest evaluation, consisting of 10 fruit inspected at ten different location was conducted for both the IPM and grower portions of the field. Results from the harvest evaluation are given in Table 8. Both the IPM and Grower side had about the same amount of clean fruit and no significant differences were determined for any of the pests using Fischer's exact test. The greatest amount of damage came from bacterial speck in the IPM portion, bacterial canker in the grower portion, as well as *other* unidentified spots.

Table 8. Harvest evaluation for the IPM portion and the grower portion of the Onondaga county field. Numbers represent total fruit out of 100.

Pest	IPM	Grower	P[b.]
Clean	79	78	1.0
Stink bug	3	2	1.0
Bacterial speck	6	1	0.12
Anthracnose	2	3	1.0
Bacterial canker	1	5	0.21
Early blight	0	2	0.50
BER[a.]	0	3	0.25
Other	9	6	0.59

a. BER - Blossom end rot
b. P values determined using a t-Test (two-sample assuming unequal variances)

The total EIQ for both portions of the field are given in Table 9. The growers portion received two additional applications of copper before bacterial speck was confirmed in the IPM portion. Thereafter both portions received the same spray applications. In addition to the products listed in Table 9 the grower also applied fertilizer regularly to the field.

Table 9. Onondaga county pesticide application for the Grower and IPM portions of the field.

Date	Spray		AI	Rate	Grower	IPM	EIQ
6/27/16	Cuprofix Ultra	Fungicide/ Bactericide	Copper sulfate	1.9 lbs/A	X		83.6

7/15/16	Cuprofix Ultra	Fungicide/ Bactericide	Copper sulfate	1.9 lbs/A	X		83.6
7/22/16	Cuprofix Ultra	Fungicide/ Bactericide	Copper sulfate	1.9 lbs/A	X	X	83.6
	Initiate 720	Fungicide	Chlorothalonil	1.7 pt/A	X	X	34.4
7/30/16	Cuprofix Ultra	Fungicide/ Bactericide	Copper sulfate	1.9 lbs/A	X	X	83.6
	Previcur Flex	Fungicide	Propamocarb hydrochloride	1.1 pts/A	X	X	17.5
8/6/16	Revus Top	Fungicide	Mandipropamid Difenoconazole	6.25 fl oz/A	X	X	5.9
	Cueva	Fungicide/ Bactericide	Copper octanoate	2 gal/A	X	X	
8/12/16	Initiate 720	Fungicide	Chlorothalonil	1.7 pt/A	X	X	34.4
	Cueva	Fungicide/ Bactericide	Copper octanoate	2 gal/A	X	X	
8/18/16	Bravo	Fungicide	Chlorothalonil	1.7 pts/A	X	X	34.4
	Portal	Insecticide/ Miticide	Fenpyroximate	2 pts/A	X	X	1.9
	Cueva	Fungicide/ Bactericide	Copper octanoate	2 gal/A	X	X	
8/23/16	Surround WP	Fungicide/ Insecticide	Kaolin	31.25 lbs/A	X	X	237.5
	Curzate 60DF	Fungicide	Cymoxanil	4.1 oz/A	X	X	5.5
	Sniper	Insecticide	Bifenthrin	6.8 fl oz/A	X	X	3.2
8/29/16	Bravo	Fungicide	Chlorothalonil	1.7 pts/A	X	X	34.4
	Cueva	Fungicide/ Bactericide	Copper octanoate	2 gal/A	X	X	
	Sniper	Insecticide	Bifenthrin	6.8 fl oz/A	X	X	3.2
9/2/16	Revus Top	Fungicide	Mandipropamid Difenoconazole	6.25 fl oz/A	X	X	5.9
	Cueva	Fungicide/ Bactericide	Copper octanoate	2 gal/A	X	X	
	Sniper	Insecticide	Bifenthrin	6.8 fl oz/A	X	X	3.2
9/8/16	Curzate 60DF	Fungicide	Cymoxanil	4.1 oz/A	X	X	5.5
	Intiate 720	Fungicide	Chlorothalonil	1.7 pt/A	X	X	34.4
9/16/16	Intiate 720	Fungicide	Chlorothalonil	1.7 pt/A	X	X	34.4
	Revus Top	Fungicide	Mandipropamid Difenoconazole	6.25 fl oz/A	X	X	5.9
TOTAL					**836**	**668.8**	

The grower stated that his overall harvest was above average and that this was the same for both portions of the field. He also stated that he was able to eliminate a few sprays and time spray applications better due to the results of weekly scouting.

Discussion

The summer of 2016 was extremely hot and dry and ideal for TSSM mites. TSSM were found at all three locations and required miticides to control them in two of the locations. The beneficial mites that were used at the Erie county site were unsuccessful this year probably due to poor timing of release. By waiting until TSSM are more abundant in the field, beneficial mites may still prove to be effective.

The scouting procedures developed in 2000 worked well for all the sites. Diseases were identified early and spray recommendations were made to limit their spread. Fungal diseases were not as prevalent this year. Late blight, a serious disease of both tomatoes and potatoes, for example, was not detected in NY at all this summer. The weather conditions were not favorable for fungal diseases and therefore growers were able to eliminate a few of their fungicide sprays.

Bacterial diseases however were a problem at all three farms and it is now known that all three farms had a history of bacterial diseases. TOMCAST, which is used to time fungicide spray applications for early blight, septoria leaf spot, and anthracnose, is not useful for farms that have a history of bacterial diseases. At all three locations TOMCAST was discontinued as soon as bacterial diseases were detected. Copper spray were recommended at each of the farms as well as rotating crops for at least three years.

The EIQs for the IPM and grower portion of the fields were very similar. This may be in part due to the influence scouting results had on spray application on not just the IPM portion but also the grower portion of the fields.

One workshop with 12 attendees was held to educate growers on tomato pests and scouting procedures. They learned when and how to scout for the various pests and thresholds for each of the pests. They were also provided with factsheets for most of the common tomato pests to make identification in the field easier.

Project location(s): Erie county, Monroe county and Onondaga county, NY

Sample of Resources developed:

Figure 1. Walnut wilt

Figure 2. Tomato with ring spots caused by SpLV.

Figure 3. Bacterial speck

Figure 4. TSSM webbing

Figure 5. TSSM damage